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Development, Reliability, and Validity of Open-ended Test to Measure Student's Digital Literacy Skill

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ABSTRACT

This study aims to developing open-ended test for measuring digital literacy skills of students. There are three step of this study, it was defining the construc and formatting objectives, validity by expert review and item administration. The open-ended test was develop based on five components of digital literacy skill: information, communication, content creation, safety, and problem-solving. The open-ended test was initially piloted on four group of samples: interviews and validity by physics expert (2 Professor, 1 Doctoral), professional teachers (N=2), and college students of graduate school (N=2). Modification were made afterwards and the test was administered to a group of science students from high school in Yogyakarta province, Indonesia (N=129). Result of this study are: (1) The open-ended test instrumen proved valid and worthy of use to measure digital literacy skill; (2) Based on expert validation, the teset is valid with CVR value 1.00; (3) the average value and standard deviation of INFIT MNSQ is .83-1.21 (fit with rasch model/good item); (4) The item has a good degree of difficulty with range of difficulty level between (moderate level). The student's digital literacy skill test can also be used to measure student's skill with very low to excellent categories.

Keywords:[1]
Digital Literacy Skill, Open-ended Test.

INTRODUCTION

The role of digital technologies in everyday life has been increasing over the past decades (Bekker, Bakker, Douma, van der Poel, & Scheltenaar, 2015). The growth of digital culture in this twenty-first century drives the use of digital resources and communication tools in school education (Kong, 2014). Students are required to express their ideas in digital media (Chan, Churchill, & Chiu, 2017). The success of students, engaged citizens and future employees has been linked to 'digital literacy'(Pangrazio, 2016). For educational professionals, the implication of students' increased engagement with digital media is that to help students develop the knowledge, skills, and dispositions to live, contribute, and thrive in the digital world of the 21st century (Redmond, 2015). The adoption of digital literacy skills to improve the quality of undergraduate learning is an important issue for the digital learning environment (Techataweewan & Prasertsin, 2018). But many institutions of higher education have not fully embraced digital literacy as a foundational literacy on par with reading, writing and arithmetic (Coffin Murray & Pérez, 2017).

It is difficult to provide an exact definition of "digital literacy" because this term has been used for a variety of meanings in the literature (Güneş & Bahçivan, 2018). Digital literacy has several elements such as critical thinking skills, creativity, constructing and evaluating information and using digital media effectively, could be developed as a result of students' digital writings (Al-Qallaf & Al-Mutairi, 2016). Students must be adept at interacting with files, creating graphics, converting files from one type to another and using Web-based tools to accomplish a sophisticated task (Frydenberg, 2015). Digital literacy enables one's participation in social networks for the creation and sharing of knowledge, and the ability supports a wide range of professional computing skills (Josie et al., 2018). Conceptualizations of digital literacy as a cultural competence, integrating aspects like basic technical skills, analyzing the media as object in itself, being critical to content and technology and acquiring learning strategies for searching and utilizing information and learning to learn (Bjørgen & Erstad, 2015)

Digital literacy often appears to amount to a minimal set of skills that will enable the user to operate effectively with software tools, or in performing basic information retrieval tasks (Buckingham, 2015). It represents a set of discrete abilities or behaviors expressed by the users of digital information systems, often in the process of inquiry (Meyers, Erickson, & Small, 2013). It relates more the actual skills and abilities of an

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individual to utilize ICT (Prior, Mazanov, Meacheam, Heaslip, & Hanson, 2016). Part of digital literacy is not just understanding how a tool works but also why it is useful in the real world and when to use it (Alexander, B., Adams Becker, S., Cummins, 2016).

Digital literacy for learning is more than just knowing how to operate the technology, but also having the right information management and critical thinking skills, as well as proper online behavi or (Tang & Chaw, 2016). So, the growing digital environments as educational tools requires research regarding learners' digital literacy (Greene, Yu, & Copeland, 2014). In this study, we focus to measure students' digital literacy skill using open ended questions. They allow researchers to uncover concepts that a closed-ended question might overlook. When concepts are not well-understood, open-ended questions "open the floor" to participants, providing critical insight into emerging research areas (Lee & Lutz, 2016).

There are several studies that focus on assessment of students skill, such as assessment of successful Intelligence (Mitana, Muwagga, & Sempala, 2019) and critical thinking skill (Saputra, Maskhur Dwi Joyoatmojo & Wardani, 2018). But not many studies have developed the instruments to measure digital literacy skills. Therefore this research develops an instrument to measure students' digital literacy abilities in the aspects of information, communication, content creation, safety, and problem solving

LITERATURE REVIEW

Components of Digital Literacy

Digital literacy comprises five major digital skills: photo-visual skills ("reading" instructions from graphical displays), reproduction skills (utilizing digital reproduction to create new, meaningful materials from preexisting ones), branching skills (constructing knowledge from non-linear, hypertextual navigation), information skills (evaluating the quality and validity of information), and socio-emotional skills (understanding the "rules" that prevail in cyberspace and applying this understanding in online cyberspace communication) (Alkali & Amichai-Hamburger, 2004). has developed a model that identifies six components of digital literacy: understanding and utlilising digital interfaces; non-linear navigation; critical-thinking and problem-solving skills in digital domains; cooperative learning and play afforded and creative design afforded by digital tools

Bawden (2008) said the four core competencies of digital literacy are: internet searching, hypertext navigation, knowledge assembly, and content evaluation. The most important components of digital literacy are common for future computer users and ICT professionals: accessing, managing, evaluating, integrating, creating, and communicating information individually or collaboratively in a networked, computer supported, and web-based environment for learning, working, or leisure (Karpati, 2011). Use technology, make use of technology to process, acquire, evaluate information, produce and communicate information is also competences of digital literacy (Hatlevik, O. E., & Christophersen, 2013).

Content of surveys measuring digital literacy skill can be ownership of digital devices, social and occupational use of digital devices, and attitudes towards the use of digital technology in training (Bollard, Kerry, Whitney, & Fidock, 2014). Reynolds (2016) offers a newly conceptualized modular framework for digital literacy that defines this concept as a task-driven "social constructivist digital literacy," comprising 6 practice domains grounded in Constructionism and social constructivism: Create, Manage, Publish, Socialize, Research, Surf.

Digital literacy results from three intersecting dimensions that are the (i) technical (ii) cognitive and (iii) social-emotional dimensions of digital literacy (Ng, 2012). Josie et al., (2018) identifies five disciplines of digital literacy: (1) information literacy, the ability to search, retrieve, manipulate, evaluate, synthesize and create digital content (2) computer literacy, the ability to operate digital hardware and software. Thus, understanding how to use multiple forms of tools is essential to understand technical know-how (3) media literacy, the ability to interact with textual, sound, image, video and social medias (4) communication literacy, the ability to communicate in traditional and innovative mediums and (5) technology literacy, the ability to adopt various technologies to a particular life situation. Thus, knowing which tool to select is an important ability and being able to adapt the tool to a particular context is equally important. In this study, we focus to measure component of digital literacy by Department of Elearning (2015):

Table 1. Component of Digital Literacy Skill

Component of Digital Literacy	Sub-category of Digital Literacy
Information	to identify, to locate, to retrieve, to store, to organize and analyze digital information, judging its relevance and purpose
Communication	to communicate in digital environments, to share resources through online tools, to link and interact with others to collaborate through digital tools, to participate in communities and networks, cross-cultural awareness
Content Creation	to create and edit new content (from word processing to images and video); to integrate and re-elaborate previous knowledge and content; to produce creative expressions, media outputs and programming; to deal with and apply intellectual property rights and licence.
Safety	personal protection, data protection, digital identity protection, security measures, safe and sustainable use
Problem Solving	to identify digital needs and resources, to make informed decisions on most appropriate digital tools according to the purpose or need, to solve conceptual problems through digital means, to creatively use technologies, to solve technical problems, to update own and other's competence

Measuring Digital Literacy Skill

In a study Greene et al., (2014) examine how critical aspects of digital literacy (i.e., SRL and EC) related to college students' learning gains while using the Internet to investigate an everyday public health and science topic. Lee (2014) focuses on measuring significant differences between before and after digital literacy education through pre- and post-performance tests and surveys. Siddiq, Gochyyev, & Wilson, (2017) develop a test attempts to measure students' ability in handling digital information, to communicate and collaborate during problem solving. Literat (2014) assesses the psychometric properties of a newly tested self-report assessment tool for media literacy, based on the twelve new media literacy skills (NMLs) developed by (Jenkin, Clinton, Purushotma, Robison, & Weigel, 2006)

Ainley, Schulz, & Fraillon, (2016) reviews the definitions of digital and ICT literacy that have been adopted in cross-national studies, investigates the approaches to the assessment of digital and ICT literacy that have been employed in those studies and articulates the criteria that should guide the development of a global measure of digital and ICT literacy skills. Another study investigated digital literacies among junior-high-school students with the aim of comparing participants' perceived digital literacy competencies and their actual performance in relevant digital tasks (Porat, Blau, & Barak, 2018).

Machala & Orešković (2014) measure the information and digital literacy activities of librarians in the national lifelong learning portal, and test the application of an Experience API (xAPI) as an information and a digital literacy assessment instrument. Prabhu (2010) focus on iCritical Thinking Certification test that was formulated by the Educational Testing Service and Certiport which provides a digital literacy baseline by measuring the ability to think critically in a technology-enabled environment. Furthermore, to the best of our knowledge, there are no studies that address the digital literacy skill in open-ended questions.

Open Ended Test

Open-ended questions are used in organizational research to explore, explain, and/or reconfirm existing ideas (Jackson & Trochim, 2002). They are different with interviews and focus groups because structured questionnaires restrict descriptions of the experience gained from a participant (Tran, Porcher, Falissard, & Ravaud, 2016). The importance of open-ended problems lies first and foremost in the fact that they break the stereotype that every problem has one correct solution (Klavir & Hershkovitz, 2014). They give responders the chance to write their answers in their own words (Lee & Lutz, 2016; Popping, 2015) and do not constrain respondents' answer choices (Schonlau & Couper, 2016). They may give new and valuable answers which are not thought by the researcher before (Gurel, Eryilmaz, & McDermott, 2015). For those reasons we focus on open-ended questions to measure student's digital literacy skill.

METHOD

Defining the Construct and Formulating Objectives

The first stage in developing the open-ended test was defining digital literacy skill and selecting the skills that should be targeted in the test. The skills targeted in the open-ended test were selected after reviewing all the above-mentioned tests in relation to the criteria by two of the co-authors. The test focuses on the following elements of digital literacy skills:

Table 2. Construct and Formulating Objectives

Component of Digital Literacy	Sub-category of Digital Literacy	Item
Information	to locate the digital information by digital media	1
	to judging its relevance and purpose	2
Communication	to share resources through online tools,	3
	to collaborate through digital tools,	4
Content Creation	to integrate and re-elaborate previous knowledge and content;	5
	to deal with and apply intellectual property rights and licence.	6
Safety	personal and data protection,	7
	security measures, safe and sustainable use	8
Problem Solving	to make informed decisions on most appropriate digital tools according to the purpose or need,	9
	to solve conceptual problems through digital means,	10

Content Validity by Expert Review

Content validation is one the psychometric procedures that index a test's validity or its ability to measure what it purports to measure (Cheng et al., 2016). It involves a panel of subject matter "experts" rating items into one of three categories: "essential," "useful, but not essential," or "not necessary." Items deemed "essential" by a critical number of panel members are then included within the final instrument, with items failing to achieve this critical level discarded (Ayre & Scally, 2014). Lawshe (1975) suggest content validity ratio (CVR) as a linear transformation of a proportional level of agreement on how many "experts" within a panel rate an item "essential" calculated in the following way. The following formula for the content validity ratio (CVR) was devised:

$$CVR = \frac{n_e - N/2}{N/2}$$

in which the n_e is the number of expert review indicating "essential" and N is the total number of expert review. The minimum value of CVR as shown on table 3.

Table 3. Minimum value of CVR

Frequency of Expert Review	Minimum value
5	.99
6	.99

7	.99
8	.75
9	.78
10	.62
11	.59
12	.56
13	.54
14	.51
15	.49
20	.42
25	.37
30	.33
35	.31
40	.29

Two physics professors, one doctor, two magister student in the Graduate School Program at Yogyakarta State University and two professional physics teacher were requested to review the 10 items. The content were requested to review each item based on the following criteria:

a. Accuracy of the information presented in the items,
b. Clarity of the words/phrases/diagrams of each item.

The reviewers reported that the open-ended test items were appropriate and relevant to measure the targeted student's digital literacy skills with the CVR score 1.00 (Table 3) . They had also given useful feedback on a few of the items that they thought required revision and all the necessary revisions were made.

Item Administration

After incorporating all the revisions, the revised version of the open-ended test was administered to 129 muslim students Grade XI and XII in MAN 1 Yogyakarta which selected randomly on science class in province Yogyakarta, Indonesia. They were 15 to 17 years old, 50 were male and 79 were female students. These students did not participate in any of the previous pilot. Item administration was following a step by Tiruneh, De Cock, Weldeslassie, Elen, & Janssen, (2017), prior to the beginning the test, the students were provided oral instruction regarding the purpose of the test, general direction on how they should respond to the items, and a request to take the test seriously and students were told at the beginning that it might take about an hour to complete.

FINDINGS

In this section, we describe the results of our analysis of the open-ended test including the internal consistency, item validity, item difficulty, item discrimination, and students' digital literacy skills.

Internal Consistency/Reliability

The internal consistency strategy is the easiest logistically because it does not require administering the test twice or having two forms of the test (Brown, 2002). It estimates relate to item homogeneity, or the degree to which the items on a test jointly measure the same construct (Henson, 2001). In this study we calculated the internal consistency using cronbach alpha formula (Cronbach, 1951):

$$\alpha = \frac{n}{n-1}\left(1 - \frac{\sum_i V_i}{V_t}\right)$$

Where n is the number of items, Vt is the variance of the total scores and Vi is the variance of the items score. In this test, we found the α =.73 (acceptable) by George & Mallery (2003) who provide the following rules of thumb:

Table 4. Cronbach's Alpha

Cronbach's alpha	**Internal consistency**

$\alpha \geq .9$	Excellent
$.9 > \alpha \geq .8$	Good
$.8 > \alpha \geq .7$	Acceptable
$.7 > \alpha \geq .6$	Questionable
$.6 > \alpha \geq .5$	Poor
$.5 > \alpha$	Unacceptable

Validity Test

Validity test is used to describe how accurately instrument scale constructs can be distinguished from one another and to what degree the constructs account for the variance found in the sample (Kayes, 2005). Twycross & Shields (2013) considered validity in quantitative studies: whether a tool measures what it sets out to measure. Both reliability and validity are fundamentally measures of the strength of the association, or ***correlation,*** between different variables and validity is the correlation between the test and a reference standard (Karras, 1997). In this study, the Pearson product-moment correlation coefficient r(S) were used to measure the strength of association between the results.

$$r(S) = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2 \sum_{i=1}^{n}(y_i - \bar{y})^2}}.$$

To determine the items are valid or not, we can compare the Pearson product-moment correlation coefficient r(S) with r_{table} (.145). If r(s) of the item > r_{table}, the items are valid and if value of Infit MNSQ = .77-1.30 the item is goodness of fit with rasch model ((Adams & Kho, 1996)).

Sample of the items:

1. George wants to study using online simulation. He search information on the internet. Please arrange the right way done by George to find valid information while searching the internet?
   ……
   ……
   ……
2. One day, Jihnny uploaded a learning situation with on line simulation to her personal social media account (whatsApp, facebook, and instagram). Samuel who saw the notification from his social media account was interested to learn it. Design a best ways, how do Jihnny share the information about online simulations using social media to Samuel!
   ……
   ……
   ……

Table 5. Analysis of Item Validity

Number of Item	r(S)	Infit MNSQ	Validity result
1	.560	.97	valid
2	.521	.99	valid
3	.486	1.06	valid
4	.642	.83	valid
5	.328	1.21	valid
6	.583	.95	valid
7	.566	.94	valid
8	.566	1.00	valid
9	.555	1.01	valid
10	.576	.92	valid

We also determine the validity of the test using Content Validity Ratio (CVR) by expert judgment and compute the index based on Lawshe's formula. The results as shown on table:

Table 6. Result of Validity test by CVR

Item	Validator 1	Validator 2	Validator 3	Validator 4	Validator 5	Validator 6	Validator 7	ne	CVR
1	3	3	3	3	3	3	3	7	1
2	3	3	3	3	3	3	3	7	1
3	3	3	3	3	3	3	3	7	1
4	3	3	3	3	3	3	3	7	1
5	3	3	3	3	3	3	3	7	1
6	3	3	3	3	3	3	3	7	1
7	3	3	3	3	3	3	3	7	1
8	3	3	3	3	3	3	3	7	1
9	3	3	3	3	3	3	3	7	1
10	3	3	3	3	3	3	3	7	1

Item Difficulty

Item difficulty is a crucial parameter for every new item added to the test (Loukina, Yoon, Sakano, Wei, & Sheehan, 2016) and highly important in education for both teachers and item writers (El Masri, Ferrara, Foltz, & Baird, 2017). Item difficulty is a measure of the percentage of students answering a question correctly and the values for the difficulty index range from 0% (very difficult) to 100% (very easy) (Tomak, Bek, & Cengiz, 2016). In other words, item difficulty is the proportion of participants that gets an item correct (Bai & Ola, 2017). To compute item difficulty of test using a program existing now (QUEST). The index range difficulty level and the result of the test as shown on table 7 and table 8.

Table 7. Index range Difficulty Level

Index	Difficulty Scale	Decision
$b \geq 2$	Very Difficult	To be discarded
$1 < b \leq 2$	Difficult	To be revised
$-1 < b \leq 1$	Moderate	Good item
$b < -2$	Easy	To be revised

Table 8 Score of Item Difficulty

Item	Index (b)	Difficulty Scale
1	.83	Moderate
2	-.91	Moderate
3	.63	Moderate
4	-.59	Moderate
5	-1.00	Moderate
6	-.71	Moderate
7	.43	Moderate
8	-.23	Moderate
9	.50	Moderate
10	1.05	Difficult

Item Discriminant

Item difficulty is an important consideration in terms of retaining or rejecting a given test item, but it does not provide sufficient information alone, we must also consider item discriminability (Perkins & Frank, 2018). Item discrimination is important statistics in terms of assessing quality of items because tests are intended to provide information about individual differences in the ability that the tests aim to measure

(Khairani & Shamsuddin, 2016). Item discrimination (α) is an index of how well the item distinguishes between people with contiguous trait levels, especially those who are high as opposed to those who are low on a trait (Tasca et al., 2016). It is used to measure the extent to which an item is a predictor of overall performance on a test (Bai & Ola, 2017). Matlock-Hetzel, (1997) provide the following rules of discriminant level as shown on table 9:

Table 9 Index Range Discriminant Level

Index Range	Discrimination Level
0.19 and below	Poor item, should be eliminated or needed to be revised
0.20 – 0.29	Marginal item, needs some revision
0.30 – 0.39	Reasonably good item but possibly for improvement
0.40 and above	Very good item

The discrimination index (ID) is calculated using the following formula (Bai & Ola, 2017)**:**

$$ID = \frac{(\overline{X}_C - \overline{X}_W)}{Std}\sqrt{p(1-p)}$$

Where Xc is the mean total score for students who have responded correctly to the item; Xw is the mean total score for students who have responded incorrectly to the item; p is the item difficulty for the item and Std is the standard deviation of the total exam scores. The discrimination index is shown as Table 10.

Table 10 Discriminant Level of Item

Item	Discriminant Index	Discriminant Level
1	.56	Very good item
2	.52	Very good item
3	.49	Very good item
4	.64	Very good item
5	.33	Good item
6	.58	Very good item
7	.57	Very good item
8	.57	Very good item
9	.56	Very good item
10	.58	Very good item

Student's Digital Literacy Skill

In this study, we focus to measure component of digital literacy by Department of Elearning (2015) such as information, communication, content creation, safety, and problem solving (table 1). The mean score of student's digital literacy skill about each component as shown on graph 1 and table 6.

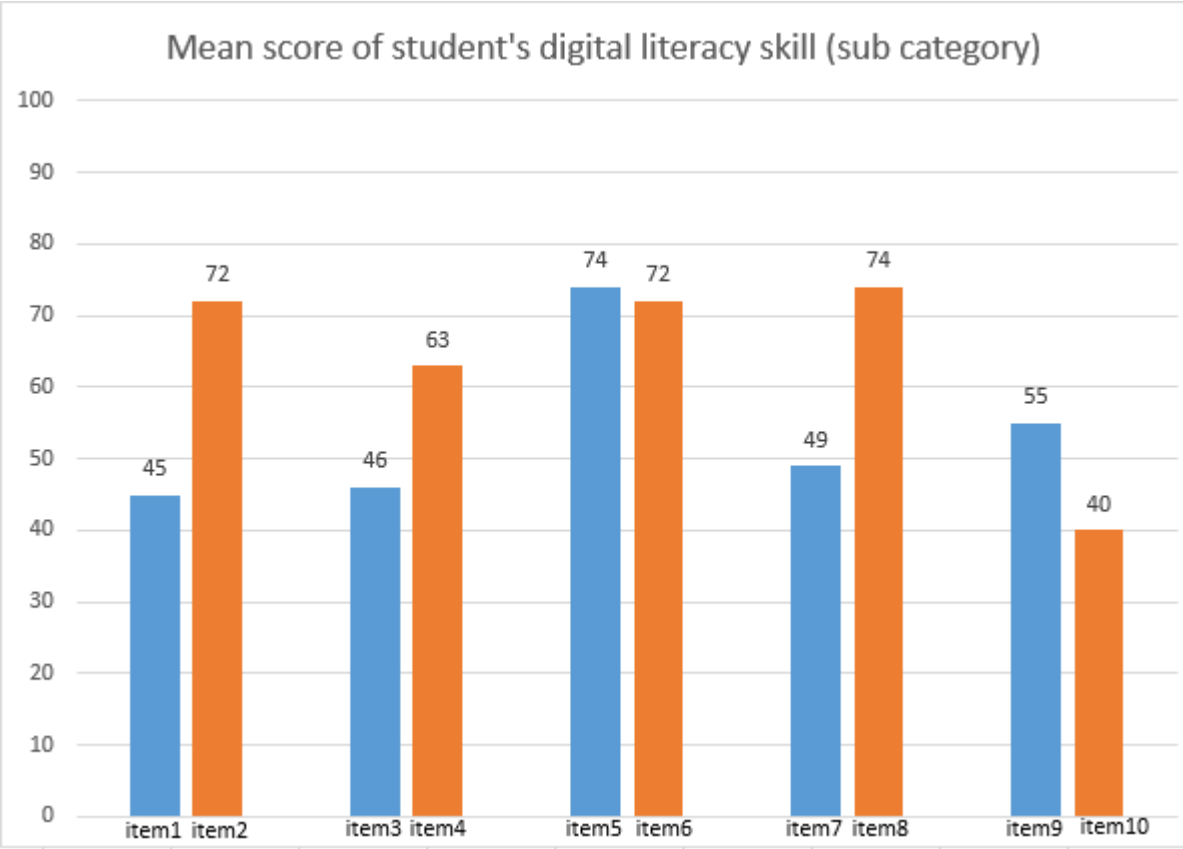

Figure 1 Mean Score of Student's Digital Literacy Skill

Table 11 Summary of Student's Digital Literacy Skill

Component	Sub-category 1	Sub-category 2	Average
Information	45	72	59
Communication	46	63	55
Content Creation	74	72	73
Safety	49	74	62
problem solving	55	40	48

Quest can also determine the ability of respondent that follow on a study (Setyawarno, 2016). The result of student's ability as shown as on Table 12.

Table 12 The Ability of Respondent

Estimate value	Students Ability	Frequency of the students
≥ 1.00	High	40
-1.00 > e > 1.00	Moderate	85
≤ -1.00	Low	4

RESULT, DISCUSSION, AND SUGGESTIONS

As the importance of developing student's skill in digital literacy, researchers and practitioners need to have valid and reliable test to evaluate the effectiveness of various instructional efforts. In this study of 129 students, we found that open ended test to measure digital literacy skill could be reliably measured using a theory-based scale. Content expert were involved during the item development stage in reviewing the items provide evidence that the test items were clear and elicited to use.

Moreover, the quantitative evidence showed that the open-ended test produced a sufficient and acceptable reliability coefficient. However, it has to be noted that the coefficient alpha was not as large as expected. The relatively low alpha value can be explained by at least two factors. First, the open-ended items were intended to elicit students' ability to demonstrate the five targeted digital literacy outcomes as outlined

by Department of Elearning (2015): information, communication, content creation, safety, and problem-solving. It is possible that the cognitive processes required to respond to the items were multifaceted. For instance, a student who performed well in an item that focuses on information analysis may not have done well on a different item that focuses on problem solving as these two components slightly vary in terms of the required cognitive processes (Tiruneh et al., 2017). Second, the lower coefficient alpha may have to do with the composition of the number of participants. Based on study literature, there are many aspect of component of digital literacy skill was suggestted. Than, for the future study, another item of digital literacy aspects can be developed. In addition, the number of samples used is also quite small, it is recommended to use a sample with a large scale to obtain more accurate results.

The test was relatively moderate (level of difficuly) and showed sufficient discriminatory value, as evidenced by the discrimination indices and the additional score group analysis. As all the open-ended items were evaluated very useful in measuring the targeted component of digital literacy during the expert review. The high score of component digital literacy is content creation and the lowest is problem-solving. Additional validation studies that involve a larger and diverse group of respondents representing the target population should be conducted to further strengthen the quantitative data set and related measures. The limitations in this study were (1) the number of participants was small, so that the results of reliability, validity, and determination were only in the sufficient category. (2) the items measured are only limited to five aspects of digital literacy, even though there are still many other aspects that need to be measured. (3) We only measuring the quality of items without comparing with other variables such as gender or student majors

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